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DUCKS UNLIMITED CANADA RYE PROJECT

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Ducks Unlimited Canada – Rye Project

Prepared for:

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1.0 Summary

The "Ducks Unlimited Canada Rye Project" was started in the fall of 1999. The primary objective of this project was to develop a commercial scale process for the extraction of arabinoxylan (rye gum), and then to begin market development for the gum and by-product fractions. Three pilot runs were undertaken, the third of which was performed in February 2003 at the Innovation Place Bio-Processing Centre in Saskatoon. The arabinoxylan product was tested for its chemical and functional properties, and several food products incorporating rye gum were prepared. Further work is required to determine the commercial potential for rye gum extraction. Ducks Unlimited is interested in creating new market opportunities for fall rye and rye fractions because of the benefit to habitat that occurs as a result of the production of winter cereals.

2.0 Background

To date, three pilot-scale extractions of arabinoxylan from rye have been conducted. The first trial, performed at POS Pilot Plant Corp. in 2000, was based on methodology developed by Dr. Sanaa Ragaee while a graduate student in the Department of Applied Microbiology and Food Science, University of Saskatchewan. The two arabinoxylan products obtained (at 4-5% yield based on the weight of rye meal extracted) were characterized by a low level of purity (25-30% arabinoxylan) and low viscosity (1% solutions exhibited viscosities of 2-3 centipoise {cps} at 25°C). Arabinoxylan refined from the products prepared at POS (to approximately 80% purity) also exhibited low viscosity (10 cps at 25°C).

The second trial, which was performed at the Innovation Place Bio-Processing Facility in 2002, incorporated modifications to the methodology employed in the POS trial. Again,

however, the arabinoxylan product exhibited a low degree of purity (37%) and low viscosity (8 cps at 25°C). However, arabinoxylan refined (to approximately 85% purity) exhibited a viscosity of 84 cps, a marked improvement over arabinoxylan refined from products prepared at POS.

The third trial, which was performed at the Innovation Place Bio-Processing Facility in February, 2003, incorporated modifications to the methodology employed in the 2002 trial, principally with respect to dewatering of the precipitated arabinoxylan product prior to drying.

Product from the third trial was further purified and tested for functionality at the College of Agriculture, University of Saskatchewan. This testing included preparation of food products, including salad dressings and ice cream, to determine potential uses for the arabinoxylan product.

3.0 Chemical and Functional Characteristics of Arabinoxylan from the Third Trial

The arabinoxylan product was recovered in three batches. Approximately 17 kg of arabinoxylan product was obtained from 1360 kg of rye flour. The purities of the arabinoxylan products ranged from 42-51%. The products contained 12-14% protein, 9-11% starch and 3-4% ash. The residual 20-30% of dry matter in the arabinoxylan products was presumed to consist mainly of soluble sugars, as had been observed in previous trials. Viscosities of 1% solutions at 25°C were 250-270 cps (300-390 cps on a dry weight basis), a very substantial improvement over the results obtained with products from previous trials.

The viscometric properties of the arabinoxylan product were compared directly to those of xanthan gum and methylcellulose over a range of temperatures (5-80°C) and concentrations (0.1-2.0%). Xanthan solutions were markedly higher in viscosity than were corresponding arabinoxylan solutions, e.g. a 1.25% solution of arabinoxylan exhibited viscosity properties

similar to those of a 0.1% solution of xanthan gum. In contrast, the viscosities of arabinoxylan solutions were quite similar to those of methylcellulose solutions.

As expected, the viscosities of arabinoxylan solutions were affected markedly by temperature and concentration, i.e. viscosity was much greater at higher concentrations and at lower temperatures. For example, the viscosity of a 1.25% arabinoxylan solution was 1500-1800 cps at 5°C; at 80°C, the corresponding viscosity was approximately 10 cps. At 5°C, the viscosity of a 0.1% arabinoxylan solution was approximately 5 cps; at 80°C, a 0.1% solution did not exhibit any increase in viscosity over a deionized water control. The viscosities of arabinoxylan solutions were not affected by pH over the range of 4-8, even when heated for up to 5 h at 80°C.

The arabinoxylan product was evaluated in several experimental food systems. The solids in a chocolate milk formulation were effectively suspended by the addition of 1% (w/v) of arabinoxylan. However, a slimy film formed on the beverage surface. Desirable viscosity was achieved in a thickened cranberry juice product by the addition of 0.5-1.0% of arabinoxylan. However, the product was unappealing in appearance and flavour. Stabilization, i.e. prevention of phase separation, of a French-style salad dressing required 1.0% of arabinoxylan, a substantially higher level than is required with xanthan gum where 0.25-0.5% is more commonly used. The high level of arabinoxylan required resulted in an undesirable lightening of the colour of the salad dressing. Arabinoxylan demonstrated acid resistance in the salad dressing, which exhibited a pH of 2.6, somewhat lower than the pH of a comparable commercial dressing (pH 3.1). Leakage of water from a starch-based milk pudding after a freeze-thaw cycle was prevented by the inclusion of 0.5% of arabinoxylan in the formulation. However, an unpleasant flavour was detected at levels of addition above 0.1%.

4.0 Conclusions

Despite the modifications incorporated into three pilot-scale trials, an arabinoxylan purity of greater than 50% could not be achieved. This was due largely, we expect, to an inability to effectively dewater precipitated arabinoxylan prior to drying. The low level of purity reduced the functionality, i.e. viscosity, of systems containing the arabinoxylan product, and would make its use uneconomic in many instances. In addition, the higher usage levels associated with the arabinoxylan product impacted the appearance of some systems and, in some cases, had a negative impact on flavour. (We expect that the negative flavour attributes of the arabinoxylan product were process related and not due to any inherent problems with the flavour of arabinoxylan.)

Over the course of the project, substantial progress was made in developing a process for commercial-scale extraction of arabinoxylan from rye. Both yields and purity were improved dramatically when comparing the two initial trials to the third and final one. The arabinoxylan product extracted was functional in several applications, but its viscosity at a particular concentration was substantially less than that of xanthan gum, which is commonly used as a viscosity modifier in food systems. It viscosity did compare well to that of methylcellulose, however. The colour and flavour of the arabinoxylan product would preclude its use in some products. As mentioned earlier, the unsatisfactory colour and flavour attributes were deemed to be process related, and very substantial improvements in colour and flavour were achieved by extracting the arabinoxylan product with ethanol.

5.0 Future Directions

Further enhancements to the extraction process are necessary in order to improve both the yield and purity (including colour and flavour) of the arabinoxylan product. Improved purity will also enhance viscosity on a weight specific basis. Extraction of arabinoxylan from high viscosity rye lines is also recommended as the soluble arabinoxylan in such lines is present in higher concentration, which should be reflected in higher gum yields, and exhibits greater viscosity on a weight specific basis. Further product testing of purified arabinoxylan is also needed to systematically identify particularly promising applications for the extracted gum. An expert evaluation of the characteristics of the gum would be valuable with respect to assessing the economic feasibility of the extraction process and identifying promising food and non-food applications for rye arabinoxylan.

6.0 Personnel

The expertise of Dr. Bob Tyler and his research group at the College of Agriculture, University of Saskatchewan was essential to analyzing the material generated in the pilot run in order to determine its chemical and functional properties. Funding from ADF paid for a portion of the time invested by the University in this project.

Management and coordination of project activities was provided by Lee Moats of Ducks Unlimited Canada, who also funded Lee's time.

7.0 Equipment

No equipment was purchased or leased for use in this project.

8.0 Project Developed Materials

Due to the fact that the project is still in fairly early stages of development, no labels or marketing material have been developed to date.

9.0 Project Photo -

Figure 1 – Steps involved in processing fall rye grain to arabinoxylan gum.

10.0 Acknowledgement

At this time, no public acknowledgements have been made regarding the contribution of funds from SAF for this project because there have been no public disclosures regarding the project.